Insects and Diseases of Fruit Nursery Stocks and Their Control

By F. L. Gambrell and R. M. Gilmer

Modern spraying equipment increases the efficiency of pest control in nursery plantings

New York State
Agricultural Experiment Station
Cornell University, Geneva, N. Y.

Bulletin No. 776

March, 1956

Contents

A publication of the
New York State Agricultural Experiment Station
Geneva, N. Y.
New York State College of Agriculture
A Unit of the State University of New York
At Cornell University

Bulletin No. 776

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Abstract

DESCRIPTIONS and control measures for the principal insects and diseases of fruit nursery stocks in New York State are presented. The publication is based largely on field and greenhouse experiments conducted over the past six years. Research on some of the pests is being continued.

Virus and virus-like diseases of stone and pome fruits are described and a virus disease control program for nurseries outlined.

Recommended formulations and approximate timing of sprays for the control of the insects and diseases discussed are brought together in a summary table for ready reference.

Introduction

THIS PUBLICATION represents the results of work conducted during the past 6 years on the control of important insects and diseases of fruit nursery stocks grown in western New York. Research on certain of these pests is still in progress.

The control of diseases and insects in the fruit nursery planting is of as great importance to the orchardist who plants the nursery tree as it is to the nurseryman who propagates the tree and grows it to salable size. Insects and diseases may reduce field stands of nursery trees, they may decrease growth lowering the final grade of the nursery tree, or they may injure the tree sufficiently to cause it to be rejected at harvest by the nursery inspector. Certain virus diseases contracted in the nursery can permanently affect the ability of an infected tree to grow or to fruit in the orchard. Such infected trees, in addition to their poor economic value to the orchardist, also serve as foci from which adjacent healthy trees in the orchard may become infected. Similarly, harmful insects and diseases may be transported to areas where they did not previously occur with shipments of nursery stocks.

Although practically all of the insects and diseases that affect fruit nursery stocks also occur on orchard trees, the importance of an individual insect or disease in the nursery often differs greatly from its

importance in the orchard. A wider choice of fungicides and insecticides is available to the nurseryman than to the orchardist who must meet strict spray residue tolerances. Because of these factors, control practices developed primarily for orchard use are not generally applicable to the nursery.

Insects and diseases are influenced in their development by climatic conditions. Consequently, their individual importance may fluctuate considerably from year to year. The recommended spray program can frequently be curtailed with obvious savings in labor and cost of materials, and for this reason the included recommendations have been purposely made as flexible as is compatible with adequate pest control.

Many of the foliage diseases due to fungal or bacterial organisms and many of the insects attacking nursery stocks can be adequately controlled by properly timed and formulated sprays. However, certain virus diseases are transmitted with propagating materials and cannot be successfully controlled by spray applications.

Virus Diseases[1]

Virus diseases are caused by ultramicroscopic agents within the cells of the host plant. Typically, the causal virus is present throughout all portions of the plant. Because of this and because most viruses are transmitted in the nursery through propagating practices, virus diseases of fruit nursery stocks cannot be controlled by spray applications of presently available materials.

Fruit nursery stocks infected with a virus often fail to show distinctive symptoms of disease or the symptoms that do occur are transient or obscure. Superficially healthy trees may actually be infected with one or more viruses which later affect their growth or fruiting habits.

Virus diseases are transmitted in the nursery in three ways, namely, (a) by use of propagating wood taken from diseased trees, (b) by propagation on diseased rootstocks, and (c) by insects. Very little is currently known about insect transmission of the various viruses of fruit nursery stocks, but it is probable that the spread of viruses within the nursery by this means is relatively unimportant. Before the advent of the present virus-free certification program, virus diseases were spread in New York nurseries mainly through the use of diseased propagating wood. Infected rootstocks are presently the important source of virus infection of nursery trees.

At least three economically important virus diseases of the stone

[1]The authors are indebted to Professors K. D. Brase of this Station and K. G. Parker of the College of Agriculture at Ithaca, who kindly edited the portion of this bulletin dealing with virus diseases.

fruits occur in New York nurseries—sour cherry yellows, necrotic ring spot, and green ring mottle. Still a fourth important disease, constriction disease of Stanley prune, is possibly of virus origin, but its etiology is not thoroughly understood. Several other virus diseases of small or unknown importance probably are present in nurseries to a limited extent. Among the pome fruits, recognized virus diseases are fortunately of rare occurrence in New York nurseries.

Virus or Virus-like Diseases of Stone Fruits

Sour cherry yellows

This is unquestionably the most important virus disease of orchard cherries in New York. A progressive decline in fruit yields, roughly dependent upon the duration of the infection, occurs in diseased sour cherry trees (14).[2] In the nursery, when infected Montmorency scionwood was propagated on mahaleb understocks, bud-take was reduced by 10 per cent and the growth of the infected trees was reduced from 20 to 50 per cent, dependent upon the individual virus isolate present (18).

Although the sour cherry yellows virus complex is common in both sweet and sour cherry varieties, distinctive symptoms of the disease occur only in certain sour cherry varieties. On young sour cherries in the nursery, the identifiable symptoms of sour cherry yellows are transient and of short duration. One or more leaves become irregularly mottled with yellow (Fig. 1) during the second or third week of June under conditions normally prevailing in western New York. The mot-

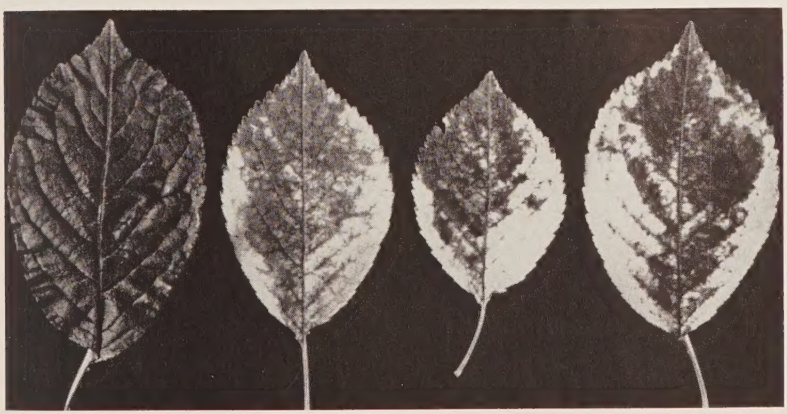

Fig. 1.—Foliage symptoms of sour cherry yellows on Montmorency sour cherry. *Left,* leaf from healthy tree; *right,* three leaves showing the typical lemon-yellow and green mottle.

[2]Refers to Literature Cited, page 49.

tled leaves drop quickly and, following their loss, the infected trees show no other symptoms except reduced growth. Leaf yellowing and dropping may be entirely lacking if high temperatures occur early in the growing season. Sour cherry yellows symptoms may be easily confused with or concealed by leaf yellowing and dropping caused by the cherry leaf spot fungus.

Sour cherry yellows was formerly spread in the nursery chiefly through the use of diseased propagating wood. The causal virus complex is also transmitted through the seeds of diseased mazzard and mahaleb trees to lining-out stocks. About 8 to 10 per cent of the lining-out stocks produced from seeds of diseased mahaleb trees may carry this virus complex (3).

Necrotic ring spot

This virus disease is very common in orchard trees and in uncertified nursery stocks of sour and sweet cherries. Although the causal virus complex can be readily transmitted experimentally to other stone fruits, such as peach or plum, necrotic ring spot is uncommon in nursery stocks of the latter fruits in New York.

Infected Montmorency nursery trees grow less vigorously than their healthy counterparts, height being more reduced than caliper (13). Bud-take is also reduced. Newly infected orchard trees of Montmorency may have their yields reduced by 40 per cent, but the infected trees gradually recover most of their bearing capacity.[3]

Leaves of infected sweet and sour cherry trees during the acute or "shock" stage of necrotic ring spot show water-soaked or chlorotic rings or lines. Areas of dead tissue, followed by shot-holing, may appear (Fig. 2). From a short distance the affected leaves often appear wavy or ruffled, and in severe cases dieback of rapidly growing terminals may occur. Terminal growth rate is sharply reduced during the acute stage of the disease, the distance between successive leaf axils is shortened, and the trees appear rosetted for a brief period. Duration of the acute stage is usually brief and is followed by apparent complete recovery. The new leaves appearing after the acute phase are symptomless or nearly so, and quasi-normal growth is resumed. Frequently in sour cherries, but less commonly in sweet cherries, trees that have recovered from the acute stage do not show evident symptoms of necrotic ring spot again. Such trees, however, are still diseased and the virus may be readily recovered from them.

Like sour cherry yellows, necrotic ring spot is transmitted in the nursery both by use of diseased propagating wood or propagation upon

[3]Unpublished data from K. G. Parker.

diseased rootstocks. The virus complex is transmissible through mazzard and mahaleb seeds, from 10 to 15 per cent of the seedlings from diseased mahaleb seed source trees being infected (8).

Fig. 2.—Foliage symptoms of necrotic ring spot complex on mazzard cherry. Similar symptoms occur on sweet and sour cherry varieties. (Photograph courtesy of K. D. Brase.)

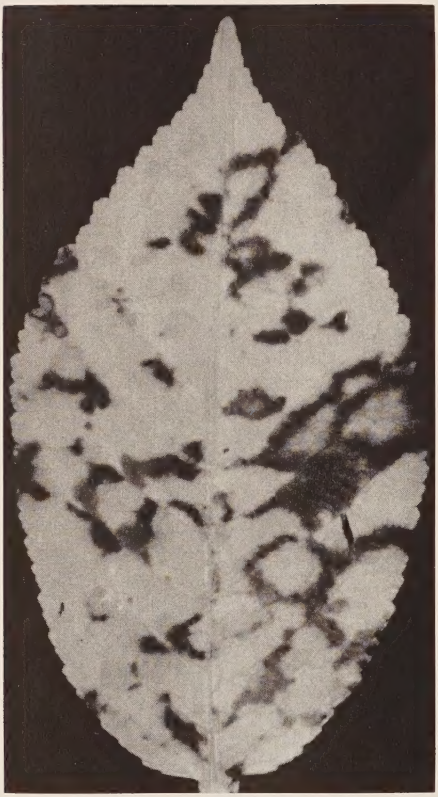

Fig. 3.—Foliage symptoms of green ring mottle on a fruiting tree of Montmorency sour cherry. The ring-like areas of deep green differentiate these symptoms from those of sour cherry yellows.

Green ring mottle

The effects of this virus disease on bud-take and growth of the nursery tree are not known, but the disease depresses fruit yields and causes necrotic pitting of fruits on Montmorency sour cherries in the orchard (19).

Green ring mottle has not been identified with certainty in commercial cherry nursery plantings in New York, but it undoubtedly occurs in nursery cherries to a limited extent. Young nursery trees often fail to show symptoms of the disease which can be readily diagnosed in fruiting Montmorency trees by the yellow leaves prominently marked with deep green blotches or rings (Fig. 3). Symptoms are usually evident about two to three weeks after symptoms of sour cherry yellows, i.e., normally from July 1 to 15 in western New York.

The causal virus is not known to be seed transmitted, although it may well be. Such transmission as occurs in the nursery is undoubtedly primarily due to the use of diseased propagating wood.

X-disease

This virus disease, fortunately, is of rare occurrence in western New York nurseries, but it is of considerable local importance in orchard plantings of peach and sweet and sour cherries in the State. Affected trees of bearing age produce unmarketable fruits of poor flavor and color, and trees of all ages commonly decline rapidly and die within a few years after infection.

X-disease causes a reddening or yellowing of peach foliage followed by defoliation. Leaves of infected Japanese plums become bright red in color. Infected sweet and sour cherries in the nursery grow very

poorly with sparse foliation and rosetted terminals. Infected trees usually decline rapidly and die. The causal virus may be carried in certain European and American or American-Japanese plum hybrids without causing evident symptoms.

Unlike the three previous viruses, X-disease virus is never carried in commercial lining-out stocks; and because infection rapidly results in poor terminal growth of affected trees, it is carried very rarely, if at all, in commercial scionwood selections. Spread in the nursery appears to be entirely through the agency of certain insect vectors and is invariably associated with the presence of diseased wild chokecherries nearby. At least three leafhopper vectors, *Colladonus clitellarius* (Say), *Scaphytopius acutus* (Say), and *Fieberiella florii* (Stal), occur commonly in western New York nurseries.

Peach yellows and little peach

These closely related virus dieases of peaches and plums occur sporadically in orchard plantings in western New York and are a serious problem in peach plantings in the Hudson Valley. Fortunately, neither disease has been found in western New York nurseries and specific control measures are not likely to be required.

Constriction disease of Stanley prune

This disorder results in poor growth and decline of Stanley prune trees in the orchard. Symptoms usually appear within three to five years after the nursery tree is planted. Apparently the same disorder reduces the growth of other plum varieties (Fellenberg and Abundance) in the nursery (2).

In the orchard, affected Stanley prune trees develop poor root systems. The poor root system is reflected by rolling of leaves, poor foliage color, and reduced terminal growth. Ultimately the tree declines and dies. A constriction occurring just below the point of union of scion and rootstock may be evident in nursery trees when they are dug (Fig. 4), but other symptoms are commonly absent in the nursery (2).

The cause of constriction disease is still obscure, but this disorder is apparently closely associated with a condition in myrobolan rootstocks termed "chlorotic fleck" (2). Chlorotic fleck, whether a virus disease or a genetic disorder, is readily transmitted through myrobolan seeds to lining-out stocks. Presently available commercial sources of myrobolan seeds and lining-out stocks show high incidences of chlorotic fleck.

Prune mottle

Prune mottle, apparently a disease of genetic origin, is present in practically all of the commercial selections of Italian prune (Fellen-

Fig. 4.—*Left,* bud union of three plum varieties grown for 3 years on myrobolan seedlings affected with chlorotic fleck. Fellenberg at left, Stanley in center, Abundance at right. Constriction at the point of union is evident only on Stanley. *Right,* myrobolan rootstock with symptoms of chlorotic fleck. (Photographs courtesy of K. D. Brase and K. G. Parker.)

berg) and a similar, if not identical, disorder occurs in several other plum and prune varieties—Grand Duke, Tragedy, Hungarian Prune, and others. In Italian prune, prune mottle is associated with premature loss of foliage and fruits in affected bearing trees. Nursery trees propagated from sources affected with prune mottle do not grow as vigorously as healthy trees (2).

Presence of prune mottle is determined by the occurrence of blotches of irregular shape and size in the leaves of affected trees. The blotches are initially yellowish-orange in color and translucent; they may vary in size from small flecks to spots almost a quarter-inch in diameter. In the late summer many of the affected leaves become yellow with spots of dead tissue. Symptoms are accentuated by hot, dry weather and in bearing trees considerable loss of foliage and fruits may occur. Prune mottle symptoms tend to be more poorly developed in nursery trees than in bearing trees and varying degrees of disease severity exist among the commercial selections of Italian prune.

Sweet cherry crinkle

This disorder is present in several sweet cherry varieties but is most frequently seen in Black Tartarian, Schmidt's Bigarreau, and Bing. Although crinkle is associated with lack of fruitfulness in bearing trees,

it does not affect the growth of young trees in the nursery to an important extent.

Crinkle is evidenced by the presence of leaves of irregular shape with distorted or irregular margins. Leaf shape may vary from almost normal to definitely strap-shaped. Foliage color tends to be paler than normal and whitish flecks or streaks may be evident in individual leaves. Symptoms are usually less pronounced in nursery trees than in trees of bearing age and mild cases of crinkle are frequently difficult or impossible to determine in the nursery tree.

Neither prune mottle nor sweet cherry crinkle has been transmitted experimentally from affected to unaffected trees, and therefore it is unlikely that either disorder is of virus origin. Although these disorders are not transmissible in the accepted sense, both may be bud-perpetuated, i.e., budlings derived from buds obtained from affected trees show the same symptoms that occur on the parent trees. Both disorders are seed-transmissible and may appear in the seedling progeny of trees that themselves do not show symptoms, a fact indicative that they may be of genetic origin. Affected seedling rootstocks, however, do not transmit either disorder to healthy scions propagated upon them.

Virus Diseases of Pome Fruits

Only three viruses of pome fruits, green mottle, apple mosaic, and pear stony pit, are presently known to occur in New York. None of them is of significant economic importance. Only apple mosaic and pear stony pit occur in New York nurseries.

Apple mosaic

This virus disease of apple is of world-wide distribution and is a serious disease in certain areas of Europe, New Zealand, and South Africa. It occurs to a very limited extent in New York orchards, but has only been found twice in New York nurseries in apple varieties of minor importance.

Leaves of affected trees are prominently variegated or blotched with creamy white areas of tissue (Fig. 5). Variegation is most prominent immediately after bud-break and is usually confined to the basal six to eight leaves of the terminals of nursery trees. Leaves developed later in the season show successively less variegation and when developed under conditions of fairly high temperatures are generally symptomless or almost so.

Present evidence indicates that apple mosaic is spread in the nursery only through the use of scionwood from diseased trees. Red Astrachan is the variety most commonly infected in the nursery, but the disease

Fig. 5.—Foliage symptoms of apple mosaic on Red Astrachan apple nursery stock. *Left,* healthy leaf; *right,* diseased leaves.

occurs in such commercially important varieties as Greening, Golden Delicious, Cortland, McIntosh, and others in the orchard.

Stony pit of pear

This virus disease disfigures the fruits of certain pear varieties with sunken pits underlaid with a hard, stony agglomeration of cells (Fig. 6). The fruits are usually considerably deformed and are commercially worthless. Stony pit has been observed in the orchard in Beurre Bosc and Worden Seckel in New York. It is probably not uncommon in Bartlett, which may carry the causal virus without showing fruit symptoms. Several other pear varieties show fruit symptoms in Oregon (10), but none of them is of commercial importance in New York.

Since recognizable symptoms of stony pit are confined to the fruits, the disease is almost impossible to detect in nursery trees. Leaf symptoms have been described but are too obscure to permit recognition of the disease in nonfruiting trees under New York conditions.

Evidence that transmission of stony pit occurs in the nursery is at present only circumstantial. If the disease does occur in New York nurseries, it undoubtedly is transmitted primarily through the use of infected scionwood.

General Aspects of Virus Disease Control in the Nursery

No method exists by which trees, once infected by a virus, may be rendered virus-free, so that present control measures are limited entirely to the prevention of infection. Because many virus infections of fruit

Fig. 6.—Fruit symptoms of pear stony pit on Bosc pears. *Left,* healthy fruit; *right,* diseased fruits. This virus disease cannot be visually determined in nonfruiting trees.

trees originate in the nursery, the initial control of virus infections devolves upon the nurseryman. Adequate virus disease control not only improves the stand and growth of nursery trees themselves, but also prevents dissemination of harmful virus diseases to the orchard.

Unfortunately, acute, identifiable symptoms of many virus diseases occur only once, and other virus diseases are characterized by fleeting annual symptoms that are usually dependent upon certain weather conditions for their appearance. Comparatively few of the economically important virus diseases of fruit nursery stocks can be readily identified at a time when the nurseryman selects scionwood for new propagations.

All of these factors hamper successful individual control of many of the virus diseases of fruit nursery stocks. To assist in the control of such diseases, a virus-free collection of commercially important stone fruit varieties is maintained at Geneva, N. Y. This collection is visually inspected at the periods critical for the appearance of symptoms of the various virus diseases, and, additionally, is annually indexed for possible hidden virus content. Scionwood from this variety collection is available to any New York nurseryman interested in the production of certified stone fruit nursery stocks, providing a few simple regulations are compiled with, as follows:

1. Buds from indexed source trees of the Geneva virus-free foundation collection may be used to propagate a *primary* nursery block. The *primary* block should be isolated by a distance of at least 100 feet from all other stone fruit nursery stocks produced from nonindexed scionwood and by at least 400 feet from mature stone fruit trees or wild species of stone fruits. (Stone fruits are defined to include all species in the genus *Prunus*, i.e., sweet cherries, sour cherries, Duke cherries, Japanese plums, European plums, *americana* plums, and their hybrids, apricots, peaches, and such ornamental species as *P. besseyi*, *P. glandulosa*, *P. maritima*, *P. pissardi*, *P. tomentosa*, and *P. triloba*. Wild species include chokecherry, pin cherry, black cherry, wild mazzard, wild plum, and wild mahaleb.)

2. Propagating wood may be taken for a period not to exceed 2 years from the *primary* block and used to propagate trees in a *secondary* block which should be isolated by at least 100 feet from stone fruit nursery stock propagated from nonindexed scionwood and by at least 400 feet from mature stone fruit trees or wild species of stone fruits. Trees from both *primary* and *secondary* blocks are eligible for certification as having been produced from virus-free propagating wood. Propagating wood from *secondary* blocks cannot be used to propagate additional certified trees.

The present certification program merely ensures that scionwood used for propagation is virus-free. Use of such virus-free propagating wood on virus-infected rootstocks will obviously result in the production of diseased nursery trees in spite of strict compliance with all of the certification regulations. In order to remedy this situation, it is necessary that large quantities of virus-free rootstocks be produced. Production of such rootstocks in quantity is difficult. Not only must virus-free seed trees of desirable horticultural type be selected, but they must be maintained in a virus-free condition for long periods of time. The production of virus-free seeds and seed trees of the various nursery root stocks has been initiated in New York and in other states.

Control of Individual Virus Diseases

Sour cherry yellows, necrotic ring spot, green ring mottle, prune mottle, sweet cherry crinkle

The diseases of this group can be greatly reduced in abundance through compliance with the certification program, i.e., by the use of indexed propagating wood. Prune mottle and sweet cherry crinkle can be completely eliminated by use of indexed propagating wood, but the remaining diseases can be only completely eliminated when large quantities of virus-free rootstocks are available.

X-disease

Since this virus disease is not ordinarily transmitted in the nursery either by propagating wood or infected rootstocks, it can be readily

controlled by removing the sources of virus inoculum upon which the insect vectors feed. All chokecherries or other wild *Prunus* species within 500 feet of the nursery should be removed. Methods of chokecherry identification and eradication may be found in Bulletin No. 704 of this Station.

Constriction disease of Stanley prune

Control of this disease is apparently completely dependent upon the selection of myrobolan rootstocks free of chlorotic fleck. Certain myrobolan lining-out stocks often show lower incidences of chlorotic fleck than other lots, and efforts should be made to reserve lots relatively free of chlorotic fleck for propagating Stanley. Production of myrobolan seed trees free of chlorotic fleck is presently underway.

Apple mosaic

This disease may be eliminated entirely from the nursery by careful visual inspection of propagating wood. Foliage symptoms of the disease are readily evident throughout the entire growing season. All trees with leaf variegation should be removed from the nursery.

Stony pit of pear

Little is known about the occurrence of stony pit in New York nurseries. Budwood selections of susceptible varieties (Bosc, Anjou, Winter Nelis, Seckel) should, if possible, be made originally from healthy fruiting trees. Experiments are currently in progress to determine whether the virus is transmissible through seeds to pear lining-out stocks.

Crown Gall and Hairy Root

These two bacterial diseases of roots and crowns of fruit nursery stocks result in an annual loss of 3 to 5 per cent of these stocks produced in New York. In badly infested soils planted to a susceptible stock such as peaches, losses as high as 40 per cent have occurred at harvest.

All of the rootstocks used in the production of fruit nursery stocks are susceptible in some degree to crown gall. Typically, most serious losses are incurred on trees propagated on peach, myrobolan, and quince rootstocks, but apple, pear, and mazzard rootstocks are almost as badly affected. Crown gall is usually an unimportant disease of mahaleb rootstocks. In addition to fruit rootstocks, the causal bacteria also attack many species of nursery ornamentals.

Crown gall injury is characterized by the presence of tumor-like excrescences on the roots of the affected plants (Fig. 7). The galls are variable in size, occasionally becoming as large as a lemon. They may

Fig. 7.—*Left,* crown gall of apple nursery stock; *right,* hairy or "mop" root of apple nursery stock.

be hard and woody in texture, but more frequently are firm and brittle. Galls may occur on any portion of the root system at or below the ground line. A common location, as the name implies, is at the crown of the plant just below the ground line.

A closely related disease, hairy or "mop" root, stimulates the formation of large numbers of fleshy adventitious roots at or near the site of the infection (Fig. 7). This disease has been observed only on apple rootstocks in New York.

Crown gall and hairy root result from infections by bacteria, namely, *Agrobacterium tumefaciens* (S. & T.) SAB and *Agr. rhizogenes* Riker, *et al.,* respectively. These bacteria are able to persist for long periods of time in the soil. They may be transported to uninfested fields by soil adhering to cultivating tools, by water run-off, by dust, or on infected plants. The bacteria are able to enter the tissues of the host plant only through wounds or abrasions, but these are normally plentifully supplied by cultivation, insects, or growth injuries.

Control

Although crown gall and hairy root have been known for many years and much research has been devoted to seeking control measures, no easy and practicable method of controlling them is yet available. Soil fumigation is, at present, too expensive and because the causal

bacteria are capable of infecting a large number of plant species enabling them to persist in soils for long periods of time their complete elimination from infested soils is essentially impossible. The amount of available bacterial inoculum, however, may be greatly reduced by following certain crop rotations.

Land should not be cropped to susceptible nursery stocks more often than every third year, and even longer rotations are desirable. Before nursery stocks are planted, land should be cropped to nonsusceptible small grains for at least two years. Fields with previous histories of heavy crown gall incidence should be avoided entirely, or at least planted to the less susceptible rootstocks such as mahaleb.

Insect Pests of Apple Nursery Stocks

A number of insect species attack nursery apples. Of these, the aphids (apple aphid, rosy aphid, grain aphid, and woolly apple aphid) and leafhoppers (apple and potato leafhoppers) are consistently injurious. Two-spotted or European red mites are often present but are only occasionally injurious. The tarnished plant bug also attacks young terminal growth of nursery apple trees but is usually of minor importance. Various leaf-eating caterpillars and beetles occasionally do minor damage by feeding on the young foliage.

Fig. 8.—Injury to 1-year-old apple trees by aphids. *Left,* normal growth; *right,* (A) apple aphids on terminal growth, (B) crooking of main stem and leaf curling by rosy aphids.

Apple aphid [*Aphis pomi* (DeGeer)]

This aphid is a common and troublesome pest of apple nursery stock of all ages (20, 21). In some seasons apple aphids become so abundant that the terminals of the nursery trees may be entirely covered with these insects by late July. Heavy infestations completely stop or kill terminal

growth, affecting both height and caliper of the nursery tree (Fig. 8A). Aphids excrete copious amounts of honeydew which often covers the foliage where aphid colonies occur. A black sooty fungus grows in this sticky substance.

The apple aphid overwinters in the egg stage on the bark of apple trees. Young nymphs begin to appear as the buds are swelling in the early spring and they may be very abundant by the time that green leaf tissue actually appears. When first hatched the young nymphs are dark green in color. The adults are yellowish-green. The apple aphid may remain on nursery apples throughout the entire summer.

Rosy aphid [*Anuraphis roseus* (Baker)]

Although the rosy aphid is commonly the most destructive aphid pest of bearing orchards, it is only occasionally an important pest in the nursery. Attacks on 1-year budlings often result in tightly curled leaves and crooked and deformed stems (Fig. 8B). Trees deformed in this manner are obviously unsalable.

The life cycle differs from that of the apple aphid (12) in that mature winged aphids migrate in June or early July to a summer host plant, narrow-leaved plaintain. In the fall, winged forms develop on plantain and return to apples where the overwintering eggs are laid.

Apple grain aphid [*Rophalosiphum fitchii* (Sand.)]

The grain aphid is not a serious pest of apple nursery stock. The life cycle is similar to that of the rosy aphid since winged forms produced in early summer migrate to their summer food plants, the grasses and small grains. Winged migrants return in the fall and overwintering eggs are deposited on the bark of apple trees.

Control of apple, rosy, and grain aphids

All three of these aphid species can be controlled either with a dormant spray to kill the overwintering eggs or by foliage applications of contact insecticides to kill the nymphs and adults (24). Records taken in 1949 showed that a dormant application with dinitro-ortho-cresol was very effective in reducing early infestations. Plots receiving the dinitro spray showed an average infestation of 0.6 per cent, while in unsprayed plots the average infestation was 6 per cent.

During the period 1950–55 foliage applications of a number of contact insecticides proved effective, either alone or in combination with various fungicides, in controlling the nymphs and adults on apple nursery stock. The materials tested included benzene hexachloride (BHC), lindane, nicotine, malathion, and parathion. Either BHC or lindane has proved generally most effective against apple aphids

(Tables 1 and 2). Parathion and malathion are slightly less effective and necessitate the use of special protective equipment by the spray operator. Nicotine is effective if temperatures are 75° F or above, but it frequently fails to give satisfactory control if sprays are necessary early in the season.

Table 1.—Control of Apple Aphid on Apple Nursery Stock by Foliage Applications of Aphicides, Geneva, N. Y., 1952 and 1955.

Aphicide	Rate*	Reduction in aphid population based on 20 terminals, per cent†
1952 Test, July 9‡		
Parathion (15% w. p.)	1–100	84
Lindane (25% w. p.)	¼–100	99
Lindane (25% w. p.)	1–100	99
BHC (10% y isomer w. p.)	2–100	100
1955 Test, June 23‡		
Malathion (25% w. p.)	2–100	100
Lindane (25% w. p.)	1–100	100

*Pounds of aphicide per 100 gallons of spray.
†Average aphid population per untreated infested terminal: 1952 test, 726; 1955 test, 1,672. Records taken 2 days after treatment.
‡Application dates: July 9, 1952; June 23, 1955.

Table 2.—Effect of Bordeaux Mixture (1½–9–100) on Aphicides Applied for Control of Apple Aphids Infesting Apple Nursery Stocks, Geneva, N. Y., 1950.

Aphicides and rates*	Fungicide	Reduction in aphid population based on 20 terminals, per cent†
Parathion (15% w. p.) 2–100	Bordeaux	99
Parathion (15% w. p.) 2–100	none	99
TEPP (20%) ½ pt–100	Bordeaux	73
TEPP (20%) ½ pt–100	none	97
Nicotine sulfate, 1 pt–100	Bordeaux	99
BHC (10% y isomer w. p.) 2–100	Bordeaux‡	99
BHC (10% y isomer w. p.) 2–100	none‡	99
BHC (10% y isomer w. p.) 2–100	none	99
BHC (10% y isomer w. p.) 2–100	sulfur§	99

*Pounds of aphicide per 100 gallons of spray unless otherwise indicated.
†Average aphid population per untreated infested terminal—1077.
‡Orthex spreader added (½ pt. per 100 gallons of spray).
§DDT (50% w. p.) added (2 lbs. per 100 gallons of spray).

Woolly apple aphid [*Eriosoma lanigerum* (Hausm)]

Injury to apple nursery stock by the woolly apple aphid has been increasing in recent years. There is evidence of a similar increase in bearing orchards in which a DDT program has been followed (16, 17).

Fig. 9.—Woolly apple aphid injury on apples. *Above left,* uninjured rooted shoot; *above right,* three shoots with typical injury on underground portion of stem. *Below,* root injury on 2-year-old tree.

Where DDT has been used extensively for leafhopper control (7) in nursery plantings, the woolly aphid also seems to be more abundant.

The economic damage caused by this aphid often exceeds that caused by any of the other aphid species attacking apple nursery stock. The injury may be of two types. Swellings appear on trunks and branches where woolly aphid colonies develop and feed. Such infestations are common at pruning scars, mechanical injuries, or close to buds. If subterranean colonies become established, galls and swellings develop on the roots and crowns of infested trees. The latter injury is often severe, and trees with seriously injured roots are unsalable (Fig. 9).

Losses of 10 to 15 per cent of harvested trees because of root injury by woolly aphid are not uncommon, and even greater losses have occurred (7). Serious injury in Malling stool plantings may occur. From 50 to 90 per cent of the rooted shoots used for lining-out stocks may be unsalable because of galls and swellings (Fig. 9). Once an infestation is established on the roots of the mother plants it may continue indefinitely unless a special effort is made to control it.

Nursery infestations may originate either from wingless viviparous females which overwinter on apple roots in the soil or from winged females which migrate to apple from American elm (Fig. 10), the al-

Fig. 10.—Woolly apple aphid injury. "Rosette" of curled leaves on American elm.

ternate plant host (1, 22). The winged migrants produce aerial colonies which are covered with a bluish-white cottony wax (4). From these aerial colonies on apple wingless aphids may move down the trunk and become established on the roots. In the late summer winged females may be again produced by the aerial colonies. These migrate to elm where the sexual forms are produced and overwintering eggs are laid. Subterranean colonies may remain indefinitely on the roots of apples.

Control of woolly aphid

The woolly apple aphid presents a special control problem, since roots and underground stems of apple as well as the trunk and branches are subject to attack.

Seedling lining-out stocks and budded stocks in the nursery can be protected by preventing establishment of aerial colonies by winged migrants from elm. Experimental data indicate that serious root injury can be checked with a vigorous spray program. In 1949, BHC, parathion, and nicotine sprays were applied on 1-year-old McIntosh apple trees in the nursery for control of the woolly apple aphid. BHC was superior to either of the other materials tested, but all three insecticides showed a significant reduction in infestation over unsprayed trees (7).

In 1950 apple seedling lining-out stocks were dipped in a BHC slurry immediately prior to planting, a second lot of lining-out stocks received a soil treatment of BHC immediately following planting, while a third lot remained untreated. Each treatment series was divided into two groups, one of which was sprayed with BHC for 3 years, while the second group received no insecticidal sprays. Results of this experiment are given in Table 3.

Table 3.—Woolly Apple Aphid Control and the Effect of BHC on Apple Seedlings, Dansville, N. Y., 1950–52.

Method of BHC application	Lining-out stocks, 1950			2-year trees, 1952	
	Per cent normal	Per cent retarded	Per cent dead	Per cent stand*	Per cent infested
Dipped at planting†	61	31	8	40	14
Dipped and sprayed	65	25	10	32	0
Drilled along row‡	91	6	3	58	4
Drilled and sprayed	97	2	2	64	0
Broadcast‡	87	10	3	63	15
Broadcast and sprayed	96	3	1	56	0
No soil treatment, sprayed§	98	2	1	69	1
No treatment	95	5	1	61	23

*Number of trees harvested per number of lining-out stocks planted.
†Lining-out stocks dipped in a slurry of 1 lb. BHC (6% y isomer w. p.) per gallon of water.
‡BHC drilled along rows or broadcast at the rate of 5 lbs. of y isomer per acre.
§Sprays consisted of five applications per season of 2 lbs. BHC (10% y isomer w.p.) plus DDT (50% w. p.) 2 lbs. plus fungicide per 100 gallons of water. In 1950–51, fungicide was ferbam (1½ lb.—100); in 1952, bordeaux 1½–9–100.

The dip treatment with BHC was both ineffective and injurious, while either soil or dip treatments without supplemental BHC spray applications did not provide complete protection against infestation. Foliage applications of BHC successfully prevented any serious woolly aphid infestation from developing regardless of soil or dip treatments.

These experiments indicate that effective aphicidal sprays must be applied throughout the entire growing period in the nursery to prevent woolly aphid injury. The sprays should be applied beginning in late May or early June and continuing until approximately July 1. This should prevent the establishment of spring migrants from elm trees. Neither dip nor soil treatments are advised in a nursery control program.

Stool blocks of the various Malling clones offer special problems in woolly aphid control. Mother plants remain *in situ* for long periods of time, and if root infestations become established annual re-infestation of the young rooted shoots may occur from subterranean aphid colonies established on the mother plants (6).

In plantings where root infestations have already become established, good control can be obtained by spraying the roots and soil about the

mother plants heavily with lindane at the time the rooted stools are removed early in the spring. Alternatively, lindane may be incorporated in the soil at the rate of 5 pounds of the gamma isomer per acre just prior to hilling up the mother plants.

As is evident from Tables 4 and 5, either of these methods of application afforded satisfactory control (9). Applications should be made annually until root infestations are entirely eliminated and should be supplemented by foliage sprays to prevent establishment of aerial infestations from elm. Newly established stool blocks can be protected by the same spray application schedules as recommended for budlings.

Table 4.—Control of Woolly Apple Aphids on Malling Rootstocks with Soil Applications of BHC, Geneva, N. Y., 1950–51.

Malling clone	Treatment	Shoots injured by aphids, per cent	Reduction in aphid injury, per cent
I	BHC*	1	95
I	none	19	—
IX	BHC*	5	83
IX	none	29	—

*BHC applied in soil around mother plants at the rate of 5 lbs. of the gamma isomer per acre. Aphicide applied on June 23, 1950, and injury counts made April 3, 1951.

Table 5.—Control of Woolly Apple Aphid Infestations on Rooted Shoots of Malling V Apple, Geneva, N. Y., 1953.

Treatment and rate*	How applied	Shoots injured by aphids, per cent	Reduction in aphid injury, per cent
Lindane (25% w. p.) 4–100	Before hilling	5	94
Lindane (25% w. p.) 4–100	After hilling	2	98
Dieldrin (50% w. p.) 2–100	Before hilling	2	98
Dieldrin (50% w. p.) 2–100	After hilling	1	99
Lindane dust (1%)	Before hilling	2	98
Dieldrin dust (1%)	Before hilling	2	98
No treatment	———	83	—

*Pounds per 100 gallons except where indicated dusts were applied. Spray mixtures applied June, 1953, at the rate of ½ gallon per foot of row (2 feet wide); dust mixtures applied at the rate of ½ lb. dust per foot of row (2 feet wide).

Potato, apple, and white apple leafhoppers [*Empoasca fabae* (Harris), *Empoasca maligna* (Walsh), and *Typhlocyba pomaria* (McA.)]

The potato leafhopper is a common and serious pest of apples in the nursery every year (11). Seedlings and budded stocks of all ages are susceptible to injury. Feeding by potato leafhopper adults and nymphs causes downward curling and scorching of the margin of the leaves and checks terminal growth (Fig. 11). Stunting of the terminal leader causes excessive lateral branching which entails heavy pruning in order

Fig. 11.—Potato leafhopper injury on 1-year-old apple tree. *Left,* normal growth; *Right,* curling of leaves and stunting of terminal growth by leafhopper feeding.

to shape the nursery tree properly. Severely injured budlings may fail to reach the desired height for "heading back".

There are at least two broods of the potato leafhopper each season. The adults initially appear about the first or second week of June, deposit their eggs in young apple tissue, and the young nymphs emerge about the third week of June. The nymphs prefer young, partially grown leaves for feeding. By late July, first brood adults predominate and in August nymphs of the second brood are numerous. The population level drops noticeably during September and October, but both

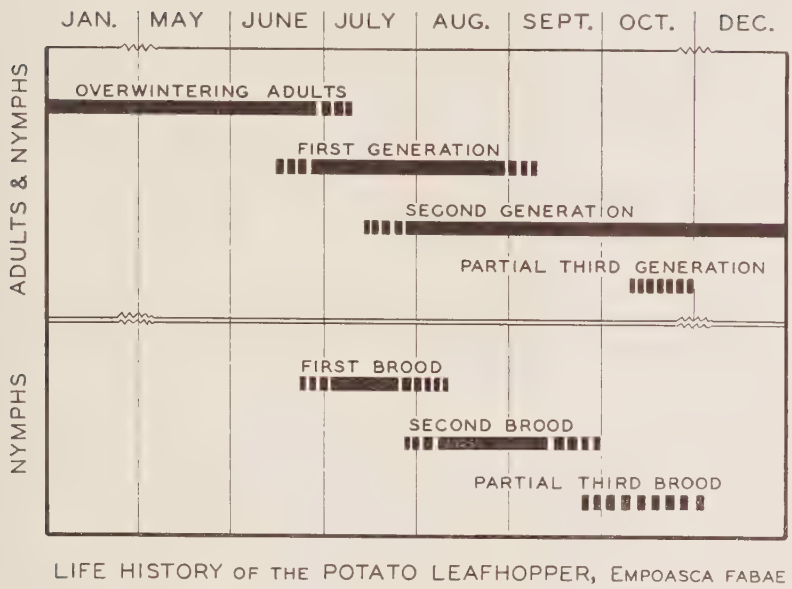

Fig. 12.—Diagrammatic sketch showing seasonal activity and life history of potato leafhopper. (After Lathrop.)

nymphs and adults are evident until freezing weather. The general seasonal activity of the potato leafhopper is portrayed graphically in Fig. 12.

The white apple leafhopper is often more prevalent on 2- or 3-year old trees. A white stippling on the upper surface of the older leaves is the typical injury caused by this species.

Control of leafhoppers

Leafhoppers infesting apple nursery stocks can be readily controlled by spraying with DDT at the rate of 2 pounds (50% wettable powder) in 100 gallons of water. The first application should be timed to eliminate as many of the overwintering adults and young nymphs as possible and normally should be applied June 10 to 15 in western New York. This period coincides closely with beginning of red color of fruit on Early Richmond cherry. Additional sprays should be applied about every 14 days until trees have reached suitable size, i.e., normally July 15 to August 1. As can be seen from Table 6, such a program affords very satisfactory control. Since this leafhopper breeds on a wide variety of host plants, apple nursery stock is frequently re-infested from areas outside the nursery.

Table 6.—Control of Potato Leafhopper with DDT on 2-year McIntosh and Cortland Apple Nursery Stocks, Dansville, N. Y., 1951.*

Dates sprayed	Dates counted	Average number leafhoppers per 10 sweeps		Control, per cent
		Unsprayed stock	Sprayed stock	
———	June 10†	15	—	—
June 18	June 18	20	—	—
July 2	July 5	110	1	99
———	July 7	108	>1	99
July 16	Aug. 4	14	1	95
Aug. 5	Aug. 8	6	>1	98

*Spray mixture contained DDT (50% w. p.) 2–100, BHC (10% y isomer w. p.) 2–100, fixed copper-lime 3–3–100.
†Adult leafhoppers first observed on June 10.

Miscellaneous pests

The tarnished plant bug [*Lygus lineolaris* (P. deB.)] feeds on a number of host plants, apples included, and occasionally may occur in large numbers on the terminals of apple nursery stocks. Baldwin and Rhode Island Greening frequently have shown a higher incidence of injury than most other commonly grown varieties in the nursery. These insects may kill the terminal buds, causing a lateral bud to assume dominance, resulting in a poorly formed tree. The red-banded leaf roller [*Argyrotaenia velutinana* (Wlk.)], green fruit worm [*Lithophane antennata* (Wlk.)], eye-spotted bud moth [*Spilonata ocellana* (D. & S.)], red-legged flea beetle [*Derocrepis erythropus* (Melsh.)], and the white apple leafhopper [*Typhlocyba pomaria* (McA.)] also attack apple nursery stocks. With the exception of the white apple leafhopper, all of these insects feed on young leaves and terminals early in the growing season. The white apple leafhopper is seldom abundant before late fall.

All of these insects can be readily controlled with DDT, but special applications are usually not necessary.

Diseases of Apple and Apple Rootstocks

Several fungus and bacterial diseases of apple occur in New York nurseries. Hawthorn rust (*Gymnosporangium globosum* Farl.) occurs as a bright orange-yellow leafspot on the leaves of several apple varieties, particularly of the ornamental crab apples. A leafspot caused by *Fabraea maculata* Atk. is also common on crab apples. These two diseases are of minor importance and seldom require control measures.

Fire blight [*Erwinia amylovora* (Burr.) SAB]

This disease is relatively uncommon on apple nursery stocks in western New York, but in exceptional circumstances where sources of

inoculum from older trees are located close to the nursery it may cause serious damage. Certain varieties, such as Cortland and Greening, are particularly susceptible to fire blight, and the susceptibility of all varieties is increased when grown on a very dwarfing rootstock such as Malling IX. The increased susceptibility of varieties on dwarfing rootstocks is directly related to their precociousness which often leads to the production of bloom in the nursery row, permitting infection through the blossoms.

Fire blight injury is first evident early in the growing season. The terminals and leaves of affected trees wilt, collapse, and turn a deep brownish-black in color. Under favorable conditions infection may proceed down a terminal into the trunk, resulting in the production of a canker covered with collapsed bark. Yellowish or amber droplets of bacterial ooze may be evident if humidity is high.

Control of fire blight

Apple nursery blocks should not be located near apple or pear orchards of bearing age. In exceptional cases where such locations cannot be avoided, two special sprays of bordeaux mixture (3–3–100) and BHC (2–100) should be applied. These sprays should be timed so that the first is applied when one-fourth of the blossoms on bearing trees are open and the second when full bloom is occurring. Infected shoots on nursery trees should not be pruned out unless pruning shears are disinfected in a bichloride of mercury solution (1 ounce per gallon of water) between cuts.

Apple scab [*Venturia inaequalis* (Cooke) Wint.]

Scab, a serious disease of bearing apples, is common on many apple varieties grown in the nursery. Although the velvety, olive-green lesions appear on apple nursery foliage every year, apple scab is seldom a limiting factor in the growth of apple nursery stock. Adequate control of apple scab is provided by the spray program recommended for the control of powdery mildew.

Apple powdery mildew [*Podosphaera leucotrichia* (E. & E.) Salm.]

Powdery mildew is the most important disease of apple nursery stocks in western New York. Jonathan, Rome, Gallia Beauty, and Monroe are very susceptible to mildew injury. Heavy infections may occur on seedling lining-out stocks and may check growth to the point where they can be budded only with great difficulty.

Symptoms of the disease usually appear in late June or early July in western New York. Affected leaves become covered with a grey-white web of mycelium and spores of the fungus. They become variously

wrinkled and deformed, and if heavily infected while very young they fail to reach normal size. On susceptible varieties, sporulation is very abundant and the leaves appear to have been heavily coated with a white powder. Systemic infections of growing terminals are common and are very conspicuous in the early spring. Systemically infected terminals grow very poorly or not at all and become much rosetted with dwarfed leaves that abscise prematurely, leaving only a compact tuft of dwarf leaves at the tip of the terminal (Fig. 13). The fungus overwinters as mycelium in the buds of systemically infected terminals or in the cleistothecial stage, small blackish-brown spherical bodies which appear on heavily infected twigs and petioles in the late fall.

Control of apple scab and powdery mildew

Copper fungicides have been used for many years to control the diseases of apple nursery stocks. Although such materials normally control apple scab satisfactorily, they are not highly effective against powdery mildew. Of the numerous organic fungicides tested, none provided satisfactory mildew control. Sulfur is quite specific against powdery mildew and is the fungicide of choice when this disease is a serious problem. It may be readily incorporated at the rate of 5 pounds per 100 gallons in any or all of the insecticidal sprays applied to apples. If applied at temperatures of 85° F or above, sulfur may cause injury and in midsummer sprays (July 1 to 15) the amount should be reduced to 2 pounds per 100 gallons if temperatures above 85° F are current when the spray is applied.

Fig. 13.—Systemic infection of terminals of Monroe apple nursery stock by apple powdery mildew. *Left,* two diseased terminals; *right,* healthy terminal.

Fig. 14.—Black cherry aphids on sweet cherry budling. *Left,* normal growth; *right,* terminal injury by aphids.

Insect Pests of Cherries

The black cherry aphid, oriental fruit moth, pear slug, and red-legged flea beetle are insects that most commonly attack sweet and sour cherries in the nursery planting. Of these, the black cherry aphid is the most common and economically important pest.

Black cherry aphid [*Myzus cerasi* (F.)]

If abundant, this insect may injure both sweet and sour cherries severely, the sweet cherry being the more severely affected. Mazzard stocks are also readily attacked, mahaleb only rarely. Heavy infestations cause curling of the leaves, stunting or cessation of terminal growth, and frequently distortion or crooking of the main stem. Injury to the main stem tends to be more pronounced and more common on sweet cherries (Fig. 14).

On sour cherries injury is likely to be localized at the tips of the terminals, especially on 2-year-old trees (Fig. 15). The incidence of infestation is usually much higher when sweet cherries are budded on

Table 7.—Black Cherry Aphid Infestation on 1-year Black Tartarian Sweet Cherry Nursery Stock in Relation to Type of Rootstock, Dansville, N. Y., 1948.

Type of rootstock	Distance from nearest mazzard rootstocks	Trees infested, per cent
Planting No. 1		
Mazzard	0 feet	91
Mahaleb	3.5 feet	90
Mahaleb	17.5 feet	16
Planting No. 2		
Mazzard	0 feet	100
Mahaleb	3.5 feet	92
Mahaleb	17.5 feet	10

to mazzard rootstocks than on mahaleb (Table 7). Injury to budlings may be so severe that the trees fail to reach commercial size.

The black cherry aphid overwinters in the egg stage on the bark of cherry trees. The eggs hatch as soon as the bud scales swell, and very heavy infestations may develop by the time that green tissue has appeared. In late June winged forms develop and migrate to the summer hosts, such as peppergrass, on which winged forms again develop in the late fall. The latter return to cherries where the sexual forms are produced and the overwintering eggs are laid.

Fig. 15.—Black cherry aphids on Montmorency sour cherry tree. Infestation of young leaves and terminal growth.

Control of black cherry aphid

The control of the black cherry aphid is similar to that of apple or rosy aphids on apple nursery stocks. A dormant dinitro spray application to kill the overwintering eggs is preferable to foliage applications with lindane because it prevents an early initial build-up of aphids on the young buds. For best results foliage applications should be made early in the season before the leaves have

become badly curled from early feeding injury. Frequency of foliage applications of aphicides, either alone or with a fungicide, will be determined by aphid populations present in the planting.

Although several aphicides are effective in cherry aphid control (Table 8), lindane is preferred to benzene hexachloride because there is less danger of foliage injury to young tender leaves of both sweet and sour cherries.[4] Nicotine, while effective under conditions of high temperatures during the summer, may not be effective in sprays applied early in the season.

Table 8.—Control of Black Cherry Aphids on Sour Cherry Nursery Stocks by Insecticidal Sprays, Dansville, N. Y., 1950, and Geneva, N. Y., 1955.

Insecticide and rate*	Reduction in aphid population based on 20 terminals, per cent†
1950 Test, June 6, 20, July 3	
Parathion (15% w. p.) 2–100	99
BHC (10% y isomer w. p.) 2–100	99
Nicotine sulfate 1 qt.–lime 1–100	99
1955 Test, June 23	
Malathion (25% w. p.) 2–100	100
Lindane (25% w. p.) 1–100	100

*Pounds of insecticide per 100 gallons of spray.
†Average aphid population per untreated infested terminal: Dansville, 1,197; Geneva, 1,677. Records taken two days after last treatment.

Miscellaneous pests

The oriental fruit moth [*Grapholitha molesta* (Busk.)] occasionally attacks cherry terminals, killing them back for a length of 1 to 2 inches. The potato leafhopper, although it also breeds on cherries, is a much less serious pest than on apples. Immature foliage is occasionally damaged by the red-legged flea beetle and the pear slug (*Caliroa cerasi* L.) skeletonizes foliage late in the season.

Control of miscellaneous pests

Special sprays to control these insects are usually unnecessary. All of these species are readily controlled by DDT, which may be added to any of the fungicidal sprays normally applied to cherries in the nursery.

Diseases of Cherries and Cherry Rootstocks

In the western New York nursery area, leafspot and powdery mildew are important diseases of cherries and of mazzard and mahaleb cherry rootstocks. Leafspot is injurious to both rootstocks and to sweet and

[4]These tests were conducted in cooperation with Dr. H. C. Young, Jr., formerly of this Station.

sour cherries. Serious injury from powdery mildew is usually confined to sour cherries, although the disease also occurs on sweet cherries and mazzard rootstocks. Mahaleb rootstocks are immune from powdery mildew.

Major injury from leafspot is incurred in May, June, and early July in western New York. After this period further progress of the disease is usually checked by dry weather. Outbreaks of leafspot commonly occur again in September, but because the nursery tree has achieved most of its growth by this time these cause little economic injury. The early season infections, however, are capable of reducing grade and caliper by inducing heavy defoliation; or in the case of rootstocks, retarding growth so that they are difficult to bud.

Powdery mildew of cherries, like that of apples, is a disease typical of mid- or late-summer. Powdery mildew flourishes in periods of low rainfall, particularly if the nights are cool with heavy dews.

The combined injury from leafspot and powdery mildew varies considerably from year to year. Generally the seasons most favorable for leafspot are not particularly favorable for powdery mildew; but in years when a wet spring is followed by a dry summer, the combined effect of the two diseases may be extremely serious. Leafspot is a serious disease of nursery cherries practically every year, while mildew causes damage in perhaps two years out of five.

Leafspot (*Coccomyces hiemalis* Higgins)

Common names for this disease are "yellow-leaf" when it attacks cherries or "rust" when it occurs on mahaleb. The term "yellow-leaf"

Fig. 16.—Leafspot on Montmorency sour cherry tree. *Left,* healthy leaf; *center,* upper surface of infected leaf; *right,* lower surface of infected leaf. The lower surfaces of the lesions are often covered by a white exudate of spores.

should not be confused with yellowing and defoliation due to sour cherry yellows virus.

Symptoms of leafspot generally appear about June 10 to 15 in western New York. Small, purple-brown spots appear on the leaves, often scattered at random over the entire leaf but more frequently concentrated near the tip. On the undersurface of the leaf these spots are covered with a white exudate containing thousands of spores of the fungus (Fig. 16). Affected leaves quickly turn yellow and abscise. Characteristically, defoliation commences with the older leaves at the bases of the terminals, and if inoculum is plentiful and the weather favorable, trees may be almost completely defoliated by July 15.

Powdery mildew [*Podosphaera oxyacanthae* (DC) DBy]

Old, fully matured leaves are resistant to infection, while immature leaves are particularly susceptible. If the leaf is well-matured at the time infection occurs, powdery mildew is evident only as a sparse white film on the undersurface. The affected areas are often visible from the upper surface because of their light coloration. Infected younger leaves are variously crinkled and deformed or reduced in size. Fungus growth is much more evident and may occur on either or both leaf surfaces (Fig. 17). Late in September abundant tan to black cleistothecia appear thickly scattered over the whitish fungus growth. These spore-bearing bodies are slightly smaller than a pin-head in size.

Fig. 17.—Cherry powdery mildew on Montmorency sour cherry.

Severe infections retard the growth of the terminals and may cause it to cease completely. Systemic infections of the terminals do not occur in the case of cherry powdery mildew, but the reduction in

leaf surface and heavy drain of foods from the host plant may reduce growth considerably.

Control of leaf spot and powdery mildew

As with apple nursery stocks, copper fungicides have long been used in the control of cherry diseases. While these fungicides are very effective in controlling cherry leafspot, their performance in controlling powdery mildew is not highly satisfactory and in some formulations they have occasionally proved phytotoxic under adverse weather conditions. In 1951 fungicide tests were begun to determine whether any of the organic fungicides might prove superior to copper fungicides in controlling cherry diseases.

As can be seen from Table 9, all of the fungicides gave some degree of leafspot control. Bordeaux mixture at the concentrations 1½–6–100 or 3–6–100 proved the most satisfactory. Phenyl mercury acetate (PMA) was extremely phytotoxic when applied after June 15. None of the fungicides tested gave adequate mildew control (Table 9). The same trends were evident in sweet cherries (variety Black Tartarian) with the same materials, but there was considerable injury from the bordeaux formulations in these plots. The effects of leafspot control on growth and grade of the nursery trees are given in Table 10.

Continued trials were made in 1952–55. In 1954 a severe outbreak of leafspot and powdery mildew occurred. Actidione, which was first tested on nursery stock in that year, gave outstanding control of leafspot, but no better control of powdery mildew than occurred in the

Table 9.—Effect of Various Fungicides on the Control of Leafspot and Powdery Mildew of Montmorency Sour Cherry Nursery Stock, Dansville, N. Y., 1951.

Fungicide and rate*	Leaves injured by leafspot, per cent†		Percentage of mildewed leaves per terminal, Sept. 5
	July 17	Aug. 28	
Ferbam 3–100: ferbam 1½–100‡	49	72	34
Bordeaux 1½–6–100	37	37	24
Bordeaux 3–6–100	34	38	22
Phenyl mercury acetate 1 pt.–100	33	48	34
No treatment	61	98	—§
LSD 19:1	9	18	
99:1	13	24	

*Pounds per 100 gallons of spray unless otherwise indicated. Sprays were applied on June 26, July 11, July 27.

†Summation of leaves lost by defoliation plus leaves with five or more leafspot lesions. Some defoliation occurred in the bordeaux and PMA plots because of spray injury, but this could not be separately assessed.

‡Application of June 26 was at 3–100; the two successive applications were at the rate of 1½–100.

§Data could not be taken because of almost complete defoliation by leafspot.

copper fungicide plots (Table 11). Sulfur was added to actidione in 1955 as an adjuvant for mildew control and this formulation gave

Table 10.—Effect of Various Fungicides on Caliper, Height, and Percentage Grade 1 Trees of Montmorency Sour Cherry Nursery Stock, Dansville, N. Y., 1951.

Fungicide*	Average caliper†	Average height‡	Grade 1 trees at harvest, per cent§
Ferbam	10.3	45	87
Bordeaux 1½–6–100	13.2	48	94
Bordeaux 3–6–100	12.9	47	92
Phenyl mercury acetate	9.9	41	81
No treatment	10.0	43	83
LSD 19:1	2.3	7	8

*Dates of application and rates as in Table 9.
†Caliper is expressed in sixteenths of an inch measured at a point 3 inches above the union of scion and rootstock.
‡Height expressed in inches from point of union to tip of central leader.
§Grade 1 trees are those with a minimum caliper of 9/16 inch and a minimum height of 42 inches.

Table 11.—Effect of Fungicides on the Control of Leafspot of Montmorency and Morello Sour Cherry Nursery Stock, Geneva, N. Y., 1954.

Fungicide and rate*	Leaves injured by leafspot, per cent†			
	Montmorency		Morello	
	July 20	Aug. 11	July 20	Aug. 11
Actidione 2 ppm	3	3	1	2
Captan 1½–100	9	14	10	16
Bordeaux 1½–3–100	8	12	8	15
No treatment	17	43	20	45
LSD 19:1	6	10	7	11

*Pounds per 100 gallons of spray unless otherwise indicated. Applications were made on June 12, June 28, July 11, July 26.
†Summation of leaves lost by defoliation plus leaves with five or more leafspot lesions.

Table 12.—Control of Leafspot and Powdery Mildew of Montmorency Sour Cherry Nursery Stock, Geneva, N. Y., 1955.

Fungicide and rate*	Leafspot injury, per cent†	Terminals with mildew, per cent
Actidione 2 ppm	2	88
Actidione 2 ppm plus sulfur 2–100	3	8
Bordeaux 1½–3–100	8	83
No treatment	20	96
LSD 19:1	8	9
99:1	—	13

*Pounds per 100 gallons of spray unless otherwise indicated. Applications were made on June 16, July 1, July 15, August 1.
†Summation of leaves lost by defoliation plus leaves with five or more leafspot lesions.

Table 13.—The Effect of Various Fungicides on Caliper, Height, and Percentage Grade 1 Trees of Montmorency Sour Cherry Nursery Stock, Geneva, N. Y., 1954–55.

Fungicide and rate*		Average caliper†		Average height‡		Grade 1 trees, per cent§	
1954	1955	1954	1955	1954	1955	1954	1955
Bordeaux 1½–3	Bordeaux 1½–3	8.3	13.6	42	49	61	95
Captan 2 lbs.	Actidione 2 ppm-sulfur 5 lbs.	7.7	12.9	40	49	38	93
Actidione 2 ppm	Actidione 2 ppm	8.1	13.5	42	48	58	95
None	None	7.3	12.5	39	48	27	90
LSD 19:1		.4	.8	NS	NS		
99:1		.6	—				

*Rates in pounds per 100 gallons of spray mixture unless otherwise indicated.
†Expressed in sixteenths of an inch measured at a point 3 inches above the union of scion and rootstock.
‡Expressed in inches measured from the point of union to the tip of the central leader.
§Grade 1 trees are defined as those with a minimum caliper of 9/16 inch and a minimum height of 42 inches.

excellent control of both diseases (Table 12). The effects of a 2-year fungicide program on growth can be seen in Table 13.

Actidione plus sulfur (2 ppm and 5 pounds per 100, respectively), bordeaux mixture (1½–3–100), and practically all types of fixed coppers (26 per cent metallic copper) plus lime (3–3–100) will give excellent leafspot control in the nursery. However, only the first formulation will give adequate mildew control. Initial sprays should be applied about June 10 to 15, and then at approximate 14-day intervals until a total of four sprays has been applied. The last application may be frequently safely omitted.

Insect Pests of Peach Nursery Stocks

The tarnished plant bug, oriental fruit moth, peach aphids, and peach tree borer may all injure peach nursery stocks. The tarnished plant bug is a common and abundant pest and may cause considerable injury in many seasons.

Tarnished plant bug [*Lygus lineolaris* (P. de B.)]

This insect overwinters as adults under leaves, stones, or other debris that may offer concealment and protection. The adults emerge in late March and early April and feed on a wide variety of weeds and grasses from which they migrate to peach or other nursery stock about mid-June. The adults, commonly called "stingers", feed on the buds of the terminal and lateral shoots of peach by puncturing the soft tissue and sucking out the plant juices. Frequently, adults puncture the stem and deposit eggs in the plant tissues. These punctures may kill the

buds causing growth to stop. Following the injury lateral buds often develop into new shoots which in turn may be attacked. The repeated attacks cause the tree to become very bushy in habit rather than developing into a normal straight upright form (Fig. 18). This condition is commonly termed "stop-back" (5, 23), and since budded peach trees are grown for only a single year in the nursery, stop-back may result in considerable reduction in caliper, height, and consequent grade.

Fig. 18.—Tarnished plant bug injury on 1-year-old peach tree. *Left,* stunting and stop-back of terminal by tarnished plant bug; *right,* normal growth of main stem.

Control of tarnished plant bug

The tarnished plant bug is a strong flier and moves readily at the slightest disturbance, a habit which makes evaluation of control work in small experimental plots difficult. Repeated observations have shown that large peach blocks sprayed with DDT can be protected from serious injury. Adults usually appear in peaches in mid-June about the time that fruit of Early Richmond cherry first shows red color. From the date of their initial appearance DDT applications should be made every 7 to 10 days to keep the growing tips well covered until the trees attain satisfactory height. Four to five applications are generally sufficient to provide protection through the period critical for growth, since sufficient height may be obtained by the end of July.

Green peach aphid [*Myzus persicae* (Sulz.)] **and black peach aphid** [*Anuraphis persicae-niger* (Smith)]

These insects may attack both peach seedling rootstocks as well as

Fig. 19.—Aphid injury to peach terminals in the spring. *Left,* normal growth of peach scion; *right,* characteristic injury to foliage and main stem by aphids.

budded varieties. The presence of heavy aphid populations in the early spring often results in severe curling of the leaves, crooking of the main stem (Figs. 19, 20), or complete cessation of terminal growth.

Control of aphids

As in the case of the apple and black cherry aphid, peach aphids can be controlled either with a dormant dinitro spray or with foliage aphicides applied early in the season. Lindane is the most satisfactory foliage aphicide, but nicotine, parathion, and malathion are also generally effective. BHC should not be used because of possible foliage injury. Similarly, only dinitro sprays of the DNOC group (Elgetol, Krenite, or DNOC wettable powder) can be safely used on peaches. DN–289 or Elgetol 318 is likely to cause injury to peaches.

Miscellaneous insects

The potato leafhopper, oriental fruit moth, and peach tree borer [*Sanninoidea exitiosa* (Say)] are common insect pests of peach nursery stock. The latter species may cause considerable damage in unsprayed plantings. Infested trees must be destroyed. None of these insects are serious problems in nurseries adequately sprayed with DDT for tarnished plant bug control.

Diseases of Peach and Peach Rootstocks

Powdery mildew and peach leaf curl are occasionally injurious to peach nursery stock. Neither disease is of consistent annual importance, but occasional sporadic outbreaks may cause considerable loss. Ordinarily, special control measures for these two diseases are not required in western New York.

Powdery mildew [*Sphaerotheca pannosa* (Wallr.) Lev.]

Most of the peach varieties of commercial importance are moderately to highly resistant to powdery mildew in the nursery. A few varieties, such as Crawford's Early, and most nectarines are quite susceptible. Lovell rootstocks are moderately resistant, while Tennessee naturals and red-leafed rootstocks are quite resistant.

Characteristically, powdery mildew does not appear in quantity until quite late in the growing season (August) and thus has little opportunity to cause serious injury. A dense white coating of fungus mycelium and spores appears on the younger leaves and a minor amount of systemic infection of the terminals may occur.

Fig. 20.—Aphid injury on main stem of peach tree at harvest. The severe crooking of the main stem followed heavy aphid attack on the young terminal in the early spring. Peach tree borer injury is evident on stem at ground level.

Control of powdery mildew

If powdery mildew becomes a problem in the nursery it can be readily controlled by a spray of wettable sulfur (5 pounds per 100 gallons). Sulfur can easily be incorporated in one of the insecticidal sprays for tarnished plant bug, and a single application normally gives adequate control.

Peach leaf curl [*Taphrina deformans* (Berk.) Tul.]

Although peach leaf curl is common in western New York

nurseries, it usually does not appear in serious quantity until fairly late in the growing season (September) after the trees have almost completed growth. Infections may, however, occur in the early spring just as growth begins and such infections may result in a considerable reduction in number of salable trees. Serious injury from early leaf curl infections occurred in western New York in 1948 and again in 1952. Actual losses in field stand in 1952 amounted to 18 per cent of the salable trees in one Dansville nursery.

Early spring infections which occur when growth is rapid often become systemic in the growing points. Terminals infected in this manner grow slowly or not at all; the developing stem becomes flattened and rosetted, resulting in an unsalable tree (Fig. 21). In cases where the main terminal is completely suppressed, numerous secondary shoots are produced from buds in the leaf axils and though one of these buds usually assumes dominance, the resulting tree is either bushy or poorly formed.

The most characteristic symptoms of leaf curl are evident on the leaves. Affected leaves are variously convoluted and deformed with a thick, rubbery texture. The infected leaves may range from bright red to pale green in color (Fig. 21). Late season infections usually involve only one or two leaves of a terminal.

Control of leaf curl

Peach leaf curl is never a problem in nurseries where the normal

Fig. 21.—Severe spring infection of peach scions with peach leaf curl. Both terminals show deformation caused by systemic infection of the growing points and neither is likely to produce a salable tree.

dormant DN spray has been applied for aphid control, since this spray also kills the overwintering leaf curl fungus spores. If the dormant DN spray was omitted and early leaf curl infections are evident, a single spray of ferbam (2 pounds in 100 gallons) will prevent further infections although it will not eliminate those already present. This application should be made as early as possible, usually from May 15 to June 1, depending on the season. The earlier the application is made, the better the control of leaf curl (Table 14). It is evident from the data presented that a single ferbam application on May 20 was as effective as the two-application schedule, and that the single application made June 2 was applied too late to control many of the infections.

Table 14.—Control of Peach Leaf Curl by Fungicide Applications, Dansville, N. Y., 1952.

Fungicide	Rate*	Dates of application	Unsalable trees, per cent
Ferbam	2/100	May 20	3
Ferbam	2/100	May 20; June 2	3
Ferbam	2/100	June 2	11
No treatment	——	——	15

*Pounds per 100 gallons.

Table 15.—Rate of Spring and Summer Infestation in Relation to Dormant and Summer Applications of Miticides in Pear Leaf Blister Mite Control, Dansville, N. Y.

Variety	Treatment and rate*	Trees infested, per cent		Reduction in infestation, per cent§
		Spring†	Summer‡	
	Dormant Application, 1949‖			
Bartlett	Lime sulfur 7–100	1	15	84
	None	84	92	—
	Summer Applications, 1952			
Bartlett	Sulfur 6–100**	55	21	79
	Parathion 1–100**	83	88	11
	None	100	99	—
Clapp	Sulfur 6–100	57	40	60
	Parathion 1–100	80	82	17
	None	100	99	—
Bosc	Sulfur 6–100	77	6	94
	Parathion 1–100	96	64	32
	None	100	94	—

*Rates given in pounds per 100 gallons of water, except for lime sulfur which is expressed in gallons.
†Infestation by overwintering mites on the first leaves in the spring.
‡Infestation of leaves of growing terminals by later mite generations.
§Based on re-infestation of growing terminals in summer.
‖Commercial dormant application made on March 30, 1949.
**Applications made on June 5, 18, July 2, 16, 1952.

Insect Pests of Pear, Plum, and Quince

This group of fruit nursery stocks is not generally damaged seriously by insect pests. The tarnished plant bug, oriental fruit moth, and various aphid and leafhopper species may occur to some extent each year. The pear blister mite is a prevalent pest of pears in the nursery and of annual occurrence.

Pear leaf blister mite [*Eriophyes pyri* (Pgst.)]

This mite attacks practically all pear varieties in the nursery, at least to some extent (Fig. 22). The mites overwinter on the tree and attack the leaf tissue as soon as the bud scales open, so that injury appears very early in the growing season (15).

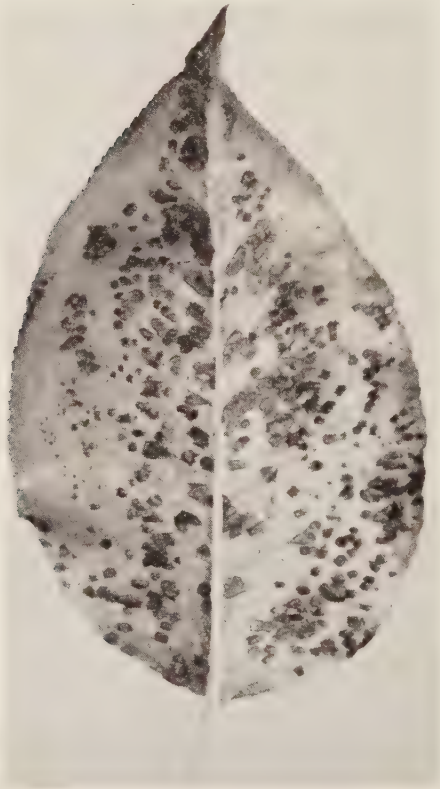

Fig. 22.—Characteristic symptoms of pear leaf blister mite injury on surface of leaf.

Control of leaf blister mite

The pear leaf blister mite can be controlled very satisfactorily with a dormant spray of lime-sulfur (1–15) to kill the overwintering mites. Attempts to control established infestations and prevent movement of mites to young leaves in 1952 were not entirely successful (Table 15). Parathion was relatively ineffective, and although sulfur afforded some control it caused injury when applications were made in hot weather.

Miscellaneous insects

The various leafhoppers, spittle bugs, oriental fruit moth, and similar insects which may occasionally cause injury in the nursery are readily controlled by DDT sprays. Special control measures are generally not required.

Diseases of Pear, Plum, and Quince

Plums, pears, and quinces are seldom sufficiently injured by plant disease to require control measures. Plums and myrobolan rootstocks may occasionally be injured by plum leafspot (*Coccomyces prunophorae* Higgins), but this disease can be readily controlled by the actidione-sulfur mixture previously recommended for cherry leafspot control.

Pears are subject to leafspots caused by *Mycosphaerella sentina* and *Fabraea maculata,* but neither disease is of sufficient importance to require control. Fire blight *(Erwinia amylovora),* a serious disease of orchard pears, is relatively uncommon on nursery stocks unless these are planted near neglected fruiting orchards. The special control measures recommended for control of fire blight under the section dealing with apple diseases are equally effective for this disease on pear nursery stocks.

Quince and quince rootstocks are often partially or completely defoliated by *Fabraea* leafspot (Fig. 23). This disease can be checked by applying one or two applications of weak bordeaux mixture (1½–3–100). The initial application should be made about June 15, and if a second application is necessary it may be made 14 days later.

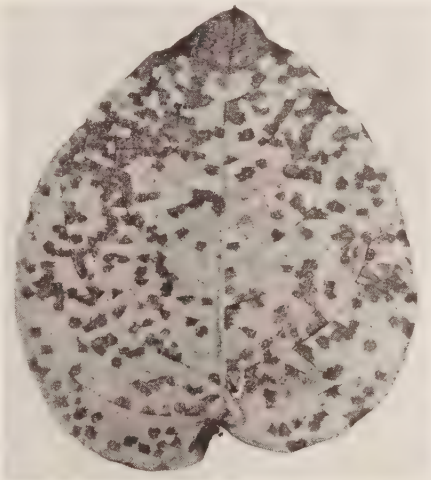

Fig. 23.—Fabraea leafspot of quince.

Recommendations for Control of Insects and Diseases

Recommended formulations and the approximate timing of sprays for the control of insect pests and diseases of fruit nursery stock are presented in Table 16.

TABLE 16.—RECOMMENDED FORMULATIONS AND APPROXIMATE TIMING OF SPRAYS FOR THE CONTROL OF THE PRINCIPAL INSECTS AND DISEASES OF FRUIT NURSERY STOCKS.*

INSECTS AND DISEASES	MATERIALS AND RATES PER 100 GALLONS	SCHEDULE	REMARKS
	APPLES		
Aphids†	1. DNC liquid (Elgetol, Krenite), 1½ qt. *or* 2. DNC—powder—(DN Dry mix) 1½ lb. *or* 3. DNBP—liquid (DN-289, Elgetol 318) 1 qt.	Late Nov. or March, April, early May	Only 1 dormant application needed; apply at least 10 or more days before buds open
Aphids†	1. Lindane (25% w.p.)‡ 1 lb. *or* 2. BHC (10% w.p.) 2 lbs.	May 15–June 1	Necessary only if DN dormant spray has been omitted
Aphids, leafhoppers, tarnished plant bug, powdery mildew, scab	1. Lindane (25% w.p.) 1 lb. *or* 2. BHC (10% w.p.) 2 lb. *plus* DDT (50% w.p.) 2 lb. *plus* 1. Sulfur 5 lbs. *or* 2. Fixed copper (26%)—lime 3 lbs. ea. *or* 3. Bordeaux 1½–3–100	Every 14 days from June 15 through Aug. 1	Sulfur is injurious if temperatures are above 85°; Aug. 1 spray can frequently be safely omitted
Fire blight	Bordeaux 3–3–100 plus BHC (10% w.p.) 2 lbs.	1. At ¼ bloom 2. At full bloom	These special sprays are usually not necessary, but should be applied if abundant inoculum is located near the nursery

PEARS			
Blister mite	Lime sulfur 1 gal.–15 gal. water	March, April, early May	Only one dormant application necessary
Fire blight	See *fire blight* under *apple*		
Fabraea leafspot, leafhoppers, spittle bug	1. Bordeaux 1½ 3 100 plus DDT (50% w.p.) 2 lbs. Fixed copper (26%)–lime 3 lbs. ea. may be substituted for Bordeaux.	June 15, July 1	Control usually is not necessary or a single application is sufficient
QUINCES			
Fire blight	See *fire blight* under *apple*		
Fabraea leafspot, oriental fruit moth	1. Bordeaux 1½–3–100 *or* 2. Fixed copper (26%)–lime 3 lbs. ea. *plus* DDT (50% w. p.) 2 lbs.	June 15, July 1, July 15	Control often not necessary and June 15 application is often only one required
PEACHES			
Aphids, leaf curl	1. DNC—liquid (Elgetol, Krenite) 1½ qt. *or* 2. DNC—powder—DN dry mix 1½ lbs.	Late November or March, April, early May	Only one dormant application needed Apply at least 10 or more days before buds open; DN-289 or Elgetol 318 should *not* be used
Aphids	Lindane (25% w. p.) 1 lb.	May 15–June 1	Necessary only if dormant DN is omitted
Leaf curl	Ferbam 2 lbs.	May 15–June 1	Special leaf curl spray when dormant DN is omitted; often unnecessary and if required may be combined with lindane for aphid control
Tarnished plant bug, oriental fruit moth	DDT (50% w. p.) 2 lbs.	Every 7–10 days from June 15 through July 30	Sulfur 5–100 may be added to any of these sprays if powdery mildew is a problem; sulfur may be injurious if temperature is above 85°

*Materials are listed in general order of preference if several are satisfactory.
†Woolly apple aphid is not necessarily controlled by the sprays generally recommended for other aphids. See page 23 for special control measures for woolly apple aphid.
‡W. P. refers to wettable powder.

TABLE 16.—*Concluded.*

INSECTS AND DISEASES	MATERIALS AND RATES PER 100 GALLONS	SCHEDULE	REMARKS
	SWEET AND SOUR CHERRIES, PLUMS, MAZZARD, AND MAHALEB		
Aphids	1. DNC—liquid (Elgetol, Krenite) 1½ qts. *or* 2. DNC—powder—DN Dry mix 1½ lbs. *or* 3. DNBP—liquid (DN-289, Elgetol 318) 1 qt.	Late November or March, April, early May	Only one dormant application needed; apply at least 10 or more days before buds open
Aphids	Lindane (25% w. p.) 1 lb.	May 15–June 1	Necessary only if dormant DN was not applied
Leafspot, powdery mildew, aphids, leafhoppers, etc.	1. Actidione 2 ppm§ plus sulfur 5 lbs. *or* 2. Bordeaux 1½–3–100 *or* 3. Fixed copper (26%)—lime 3 lbs. ea. *plus* DDT (50% w. p.) and lindane 1 lb.	June 10–15 and every 14 days through Aug. 1.	If mildew is a special problem, actidione plus sulfur should be chosen; Aug. 1 spray can often be omitted

§Ppm refers to parts per million (by weight) of water.

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